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# MULTIMEDIA UNIVERSITY

## FINAL EXAMINATION

TRIMESTER 2, 2015/2016

**EEL4106 – HIGH VOLTAGE ENGINEERING**  
( LE )

8 MARCH 2016  
9.00 a.m – 11.00 a.m  
(2 Hours)

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### INSTRUCTIONS TO STUDENT

1. This question paper consists of 3 pages including the cover page with 4 Questions only.
2. Answer **ALL** questions. The distribution of the marks for each question is given.
3. Please write all your answers in the Answer Booklet provided.

**Question 1**

- (a) With proper labelling, draw the voltage doubler circuit suggested by Greinacher to obtain  $2V_m$ . [4 Marks]
- (b) A Cockcroft-Walton voltage multiplier has 10 stages with capacitances, all equal to  $0.03 \mu\text{F}$ . The supply transformer secondary voltage is  $130 \text{ kV}$  at a frequency of  $150 \text{ Hz}$ . If the load current is  $5 \text{ mA}$ , find
- The percentage ripple, and [4 Marks]
  - The percentage regulation. [4 Marks]
- (c) Briefly explain **TWO** advantages of resonant transformer [3 Marks]
- (d) The elements of the circuit shown in Figure Q1(d) for producing lightning impulse voltages are  $C_1 = 10 \mu\text{F}$ ,  $C_2 = 40 \text{ pF}$ ,  $R_1 = 2 \text{ k}\Omega$ ,  $R_2 = 8 \text{ k}\Omega$ . Obtain  $\alpha$  and  $\beta$  to be used in the equation  $\left( v_0(t) = \frac{V}{R_1 C_2} (e^{-\alpha t} - e^{-\beta t}) \text{ kV} \right)$  [10 Marks]

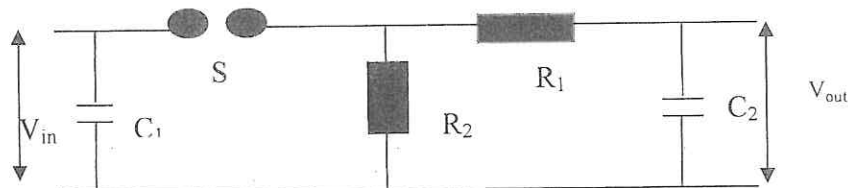


Figure Q1(d)

**Question 2**

- (a) List out **ONE** advantage and **TWO** disadvantages of uniform field electrode gaps. [3 Marks]
- (b) An electrostatic voltmeter has a movable circular plate with cross-sectional area of  $100 \text{ cm}^2$ . If the distance between the plates during a measurement is  $5 \text{ mm}$ , determine the potential difference when the force of attraction is  $0.005 \text{ N}$ . [4 Marks]
- (c) Draw a Schering bridge circuit to determine the loss factor of a specimen and derive the necessary expressions. An insulation specimen is tested at  $50 \text{ Hz}$  using the Schering Bridge. The bridge has a standard capacitor,  $C_s$  of  $100 \text{ pF}$ , a non-inductive resistor,  $R_4$  of  $500 \Omega$  in parallel with a variable capacitance  $C_4$ , and a non-inductive variable resistor  $R_3$ . If balance is obtained with  $C_4 = 0.25 \mu\text{F}$  and  $R_3 = 150 \Omega$ , determine the loss factor, capacitance and resistance of the specimen using series equivalent model. [12 Marks]
- (d) Briefly explain the following terms as applied to high voltage testing.
- Withstand voltage [2 Marks]
  - 50% impulse flashover voltage [2 Marks]
  - Disruptive discharge voltage [2 Marks]

Continued...

**Question 3**

- (a) Briefly explain the term 'breakdown' as used to describe breakdown in gaseous medium, and list out TWO mechanisms that explain the breakdown of gaseous medium under a static uniform field. [3+2 Marks]

- (b) Figure Q3 shows the void in the solid dielectric material, where  $t$  is the thickness of the cavity, and  $d$  is the thickness of the solid dielectric material.

- (i) Draw the equivalent circuit of a dielectric material with a cavity [3 Marks]  
 (ii) Derive expressions for the capacitance of the cavity,  $C_c$ , and solid dielectric material,  $C_s$ . [4 Marks]  
 (iii) Show that if a voltage  $V$  is applied across the dielectric, then the voltage

across the cavity  $V_v = \frac{V}{1 + \frac{1}{\epsilon_r} \left( \frac{d}{t} - 1 \right)}$ , where  $\epsilon_r$  is the relative permittivity.

[7 Marks]

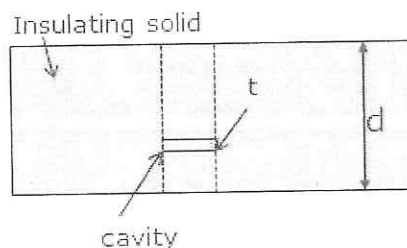


Figure Q3

- (c) The breakdown of a certain gas occurs at a uniform electric field between two plane electrodes having a spacing of 1.0 cm. If the Townsend's second ionization coefficient  $\gamma$  is 0.001 find the value of the Townsend's primary ionization coefficient  $\alpha$ . [6 Marks]

**Question 4**

- (a) List out TWO advantages and TWO disadvantages of the rod gap (horn gap). [6 Marks]

- (b) Draw the V-I curve of a surge arrester and briefly explain THREE conduction regions of V-I characteristics of the surge arrester. [8 Marks]

- (c) A rectangular voltage wave of 3000 kV is traveling along a line of surge impedance  $300 \Omega$  towards a lightning arrester. The arrester protective level is 2000 kV and is assumed to be fairly constant at all current values discharged by the arrester. Calculate

- (i) the current flowing through the line before the surge voltage reaches the arrester terminal, [2 Marks]  
 (ii) the current through the arrester, [2 Marks]  
 (iii) reflected current in the line,  $I_2$ , reflected voltage in the line,  $V_2$ , refracted voltage into the arrester,  $V_3$ , reflected coefficient of voltage and refraction coefficient of voltage, and [5 Marks]  
 (iv) the arrester's resistance. [2 Marks]

**End of Paper.**